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A catalogue of AGN observed by the PDS experiment on board BeppoSAX

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Abstract. The PDS experiment onboard BeppoSAX is the most sensitive instrument ever above 10 keV. Preliminary results on the complete catalogue of AGN observed with it are presented in this *paper*.

The Phoswitch Detector System (PDS; Frontera et al. 1997) - one of the four Narrow Field Instruments on board the Italian-Dutch satellite BeppoSAX (Boella et al. 1997) - is an array of four independent NaI(Tl)/CsI(Na) scintillation detectors. With an hexagonal collimated field of view of $1\overset{\circ}{.}3$, the PDS was designed to ensure moderate resolution spectroscopy ($\Delta E/E \leq 15\%$ at 60 keV) in the energy range between 13 and 200 keV. The accurate control of the instrumental and celestial background (at the level of one tenth of mCrab) and the unprecedented sensitivity are the most outstanding properties of this instrument, whose performances are likely to remain unsurpassed for many years to come.

In this *paper* we describe the state-of-the-art complete catalogue of Active Galactic Nuclei (AGN) observed by the PDS. Thanks to the last minute extension of the operational life of BeppoSAX, one year beyond the originally foreseen switch-off (April 2001), this is still a work in progress.

In this *paper* we consider all the PDS observations of AGN, whose data were publicly available on March 2001, and which yielded a $\geq 3\sigma$ PDS detection. For the typical exposure time of a BeppoSAX observation (50 ks), this level corresponds to a count rate of about 0.15 s^{-1}, or 1 mCrab.

1. AGN spectroscopy above 10 keV

The main goal of AGN observations above 10 keV is the direct observation of the nuclear emission of absorbed Seyferts[1]. Type 2 Seyferts suffer significant extinction in the X-ray band, mainly due to photoelectric absorption by cold matter. As long as the absorbing column density, N_H, is lower then a few

[1] In this paper we define as *nuclear* the region surrounding the supermassive black hole within a radius of the order of 1 pc, *i.e.*, the putative inner size of the putative molecular torus (see, *e.g.*, Guainazzi et al. 2000a)

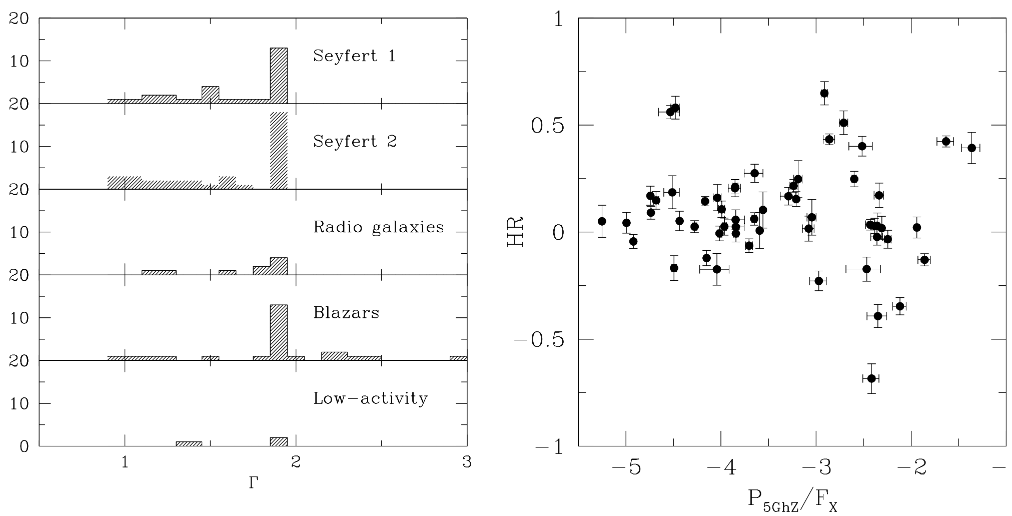

Figure 1. *Left panel*: distribution function for the PDS photon index of different classes of AGN. *Right panel*: Hardness Ratio versus ratio-to-X-ray power ratio for the whole PDS AGN catalogue

10^{24} cm^{-2}, PDS spectra are basically unaffected by absorption, and the intrinsic nuclear emission of different flavors of AGN can be directly compared[2].

The general astrophysical context of this study is the unification scenario for Seyfert galaxies (Antonucci 1993). If the observational differences between absorbed and unabsorbed AGN are indeed mainly due to the orientation of systems, that otherwise share a common nuclear engine, hard X-ray observations should allow us to observe the emission from the innermost region of the active nucleus, overcoming any "contamination" from the surrounding environment. Any Seyfert type-dependent differences in the hard X-ray properties would undermine one of the basic assumption of the unification scenario.

In Figure 1 we show the distribution function of the photon spectral indices for several classes of AGN. PDS spectra have been fit with a simple power-law model with high-energy cut-off (the latter component being required at a confidence level higher than 99% only in 4 objects). The mean of the distributions for type 1 and type 2 Seyferts are virtually indistinguishable: $\langle\Gamma\rangle_{Sy1} = 1.678 \pm 0.014$ ($\sigma_{Sy1} = 0.070$), and $\langle\Gamma\rangle_{Sy2} = 1.663 \pm 0.013$ ($\sigma_{Sy2} = 0.069$), respectively. For comparison, we show also the distribution for a the sample of radio-loud quasars (radio galaxies and blazars): $\langle\Gamma\rangle_{RG} = 1.75 \pm 0.04$ ($\sigma_{RG} = 0.104$), and $\langle\Gamma\rangle_{Bl} = 1.90 \pm 0.03$ ($\sigma_{Bl} = 0.128$), respectively. The difference seems to be related to the skeweness of the distribution around the maximum value. In the *right panel* of Figure 1 we compare the PDS hardness ratio [defined as $HR \equiv (H - S)/(H + S)$, where S and H are the counts below and above

[2]Recent BeppoSAX studies (Risaliti et al. 1999) suggest that a sizable fraction of Seyferts are totally thick to Compton-scattering, with $N_H > 10^{25}$ cm^{-2}. In this case the nuclear transmitted flux is strongly suppressed and even the PDS is of very little help.

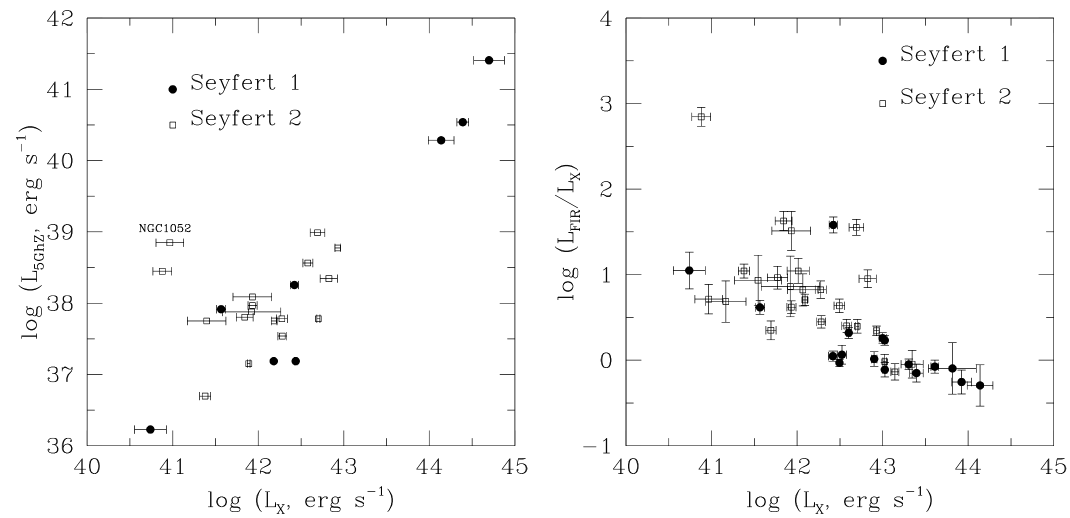

Figure 2. *Left panel*: Radio versus X-ray luminosity for the PDS AGN catalogue. The position of NGC 1052 is marked: it is a LINER, whose X-ray emission is likely to be dominated by an advection-dominated flow (Guainazzi et al. 2000b) *Right panel*: FIR-to-X-ray luminosity ratios versus the X-ray luminosity for the same sample

30 keV] against the ratio between the 5 Ghz and the 20-200 keV fluxes, R_{rx}. For $R_{rx} < 10^{-3}$, HR is confined within a narrow band around $HR = 0$, whereas AGN with a stronger relative radio power tend to suffer a substantially higher scatter of the data points, likely to be due to the dichotomy of physical processes (synchrotron and inverse Compton), dominating the blazar emission in this energy band.

2. Multiwavelenght view

The 20-200 keV luminosity, L_X of the PDS Seyferts shows clear correlations with the radio (see the *left panel* of Figure 2) and the FIR power (Figure 3). The former correlation suggests a common nuclear origin for both components. Indeed, at least 50% of the 12μm Seyfert sample show unresolved radio emission on the sub-arcsecond scale (Thean et al. 2000). The correlation between L_X and L_{FIR} is at a significance level higher than 99.9% for all IRAS bands and for both type 1 and type 2 objects, except for the 100μm band in Seyfert 1s ($\simeq$ 99%). This supports the idea that the bulk of the FIR emission in (bright) Seyferts is due to reprocessing by optically-thick matter, *e.g.* the molecular torus surrounding the active nucleus in the unification scenarios. Some objects exhibit, however, an excess of FIR emission in comparison with the members of their class of corresponding X-ray luminosity. Three of these outliners (NGC 1068, NGC 7469, and NGC 6240) are well known to host intense nuclear starbursts, which may well explain the IR excess emission in terms of dust heating by young hot stars in regions in intense star formation. Seyfert 1s and Seyfert 2s do not seem to occupy

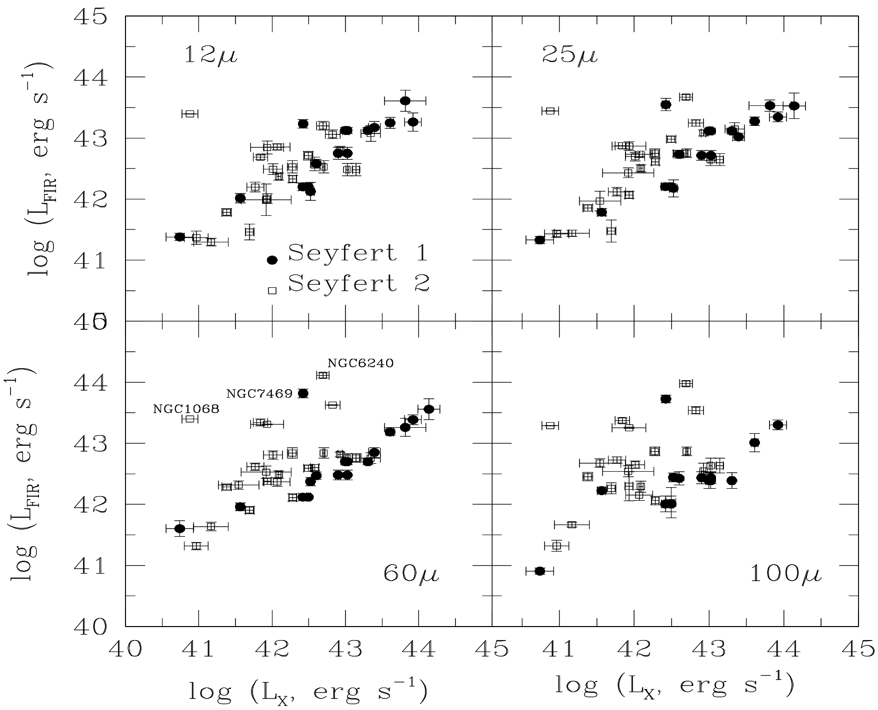

Figure 3. FIR versus X-ray correlation for the Seyfert of the PDS catalogue

the same loci in the FIR vs. X-ray plane. As shown in the *right panel* of Figure 2, for $L_X < 10^{43}$ erg s^{-1} Seyfert 2s tend to have on the average a higher FIR-to-X-ray luminosity ratio than Seyfert 1s, whereas this difference vanishes for high-luminosity objects. This would point to an increasingly important starburst contribution to the energy budget for decreasing AGN luminosity and increasing AGN "obscureness". Caution must be, however, used in the interpretation of this result, because the type 1 and 2 samples are not well matched in X-ray luminosity.

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